

Pediatric Deep Neck Infections: a 10-year retrospective single-centre study

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Helsinki, April 01, 2015

MD Thesis

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HELSINGIN YLIOPISTO – HELSINGFORS UNIVERSITET

Tiedekunta/Osasto – Fakultet/Sektion – Faculty Faculty of Medicine		Laitos – Institution – Department Clinicum, Dept. of ORL-HNS
Tekijä – Författare – Author Mikaela Römer		
Työn nimi – Arbetets titel – Title Pediatric deep neck infections: a 10-year retrospective single-centre study		
Oppiaine – Läroämne – Subject Medicine		
Työn laji – Arbetets art – Level MD Thesis	Aika – Datum – Month and year April 2015	Sivumäärä – Sidoantal – Number of pages 32
Tiivistelmä – Referat – Abstract <p>This thesis describes the characteristics and management of pediatric deep neck infections at the Department of Otolaryngology – Head and Neck Surgery at the Helsinki University Hospital during a 10-year period.</p> <p>The cohort consisted of 62 patients. A majority (85%) of the patients underwent immediate or late surgical intervention. Due to the low amount of conservatively treated patients (15%) no factors suggestive for successful conservative treatment were recognized. However, initiation of conservative treatment and close follow-up seem sufficient if the patient is in stable condition. The mean duration for hospital stay was 4.8 days. Patients with a complicated clinical course presented more likely with fever, cervical lymphadenopathy, trismus and torticollis. Despite the chosen treatment modality, all patients recovered well and the risk of serious complications was low.</p> <p>Surgical drainage still remains the main treatment modality for this patient population at our institution. Further studies are warranted to compose evidence-based treatment guidelines.</p> <p>(Words: 150)</p>		
Avainsanat – Nyckelord – Keywords Pediatric, neck, abscess, parapharyngeal, retropharyngeal, treatment, surgery, outcome		
Säilytyspaikka – Förvaringställe – Where deposited		
Muita tietoja – Övriga uppgifter – Additional information		

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1 INTRODUCTION

Pediatric deep neck infections (DNI) are characterized as fairly common clinical conditions (1-5). Pediatric DNIs are abscesses located in the deep cavities of the neck. They usually arise as complications of upper respiratory tract infections or dental infections. Among pediatric patients the cause is rarely a trauma of the head and neck region. Due to their location in deep spaces and cavities of the neck and their capability of further spread towards the mediastinum and the skull they are potentially life-threatening (1). Because of possible complications such as mediastinitis, airway obstruction or even an aneurysm of the carotid artery it is important to recognize them early.

The diagnosis is based on clinical evaluation and radiological imaging but the specific mode of treatment has been under wide discussion during the past 10 years. The literature does not present clear guidelines as to whether a patient should be conservatively treated with intravenous antibiotics or operatively treated with drainage of the abscess either transorally or externally through the neck. Various studies have aimed at composing a treatment guideline to guide the clinician in the decision making but no convincing treatment algorithms have been published (2,6). According to previous research the outcome of the treatment remains good and the rate of complications will be low regardless of the treatment modality chosen (2,4,7).

Earlier Finnish research exists on this topic, but the focus has been on patients in general rather than mere pediatric patients (5,8-10). Therefore, it was of interest to investigate the characteristics of pediatric deep neck abscesses, the choice of treatment and the outcome of the treatment for pediatric DNIs in a Finnish patient population.

2 REVIEW OF THE LITERATURE

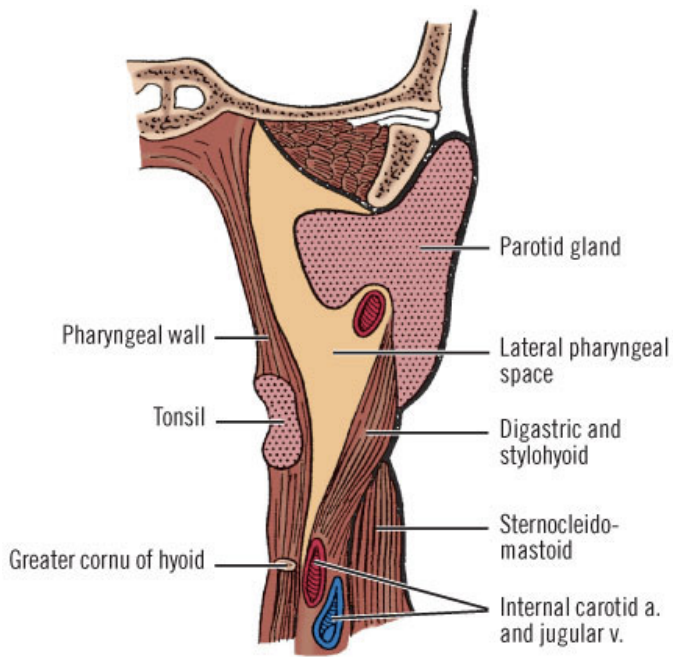
2.1 Background

2.1.1 Anatomy

Understanding the anatomy of the neck is helpful in understanding the localization and way of spread of the deep neck infections. The deep neck spaces are cavities lined by muscles, muscle fascias and other anatomical structures of the neck. They are lined by *fascia cervicalis superficialis* and *fascia cervicalis profunda*, the superficial and deep fascia of the neck. Deep neck infections are localized within cavities lined by *fascia cervicalis profunda*. Due to the build-up of these spaces infections may spread through one cavity to the other, therefore possessing the ability to lead to a potentially wide-spread infection. Retropharyngeal processes may be complicated because this space is directly connected to the mediastinum.

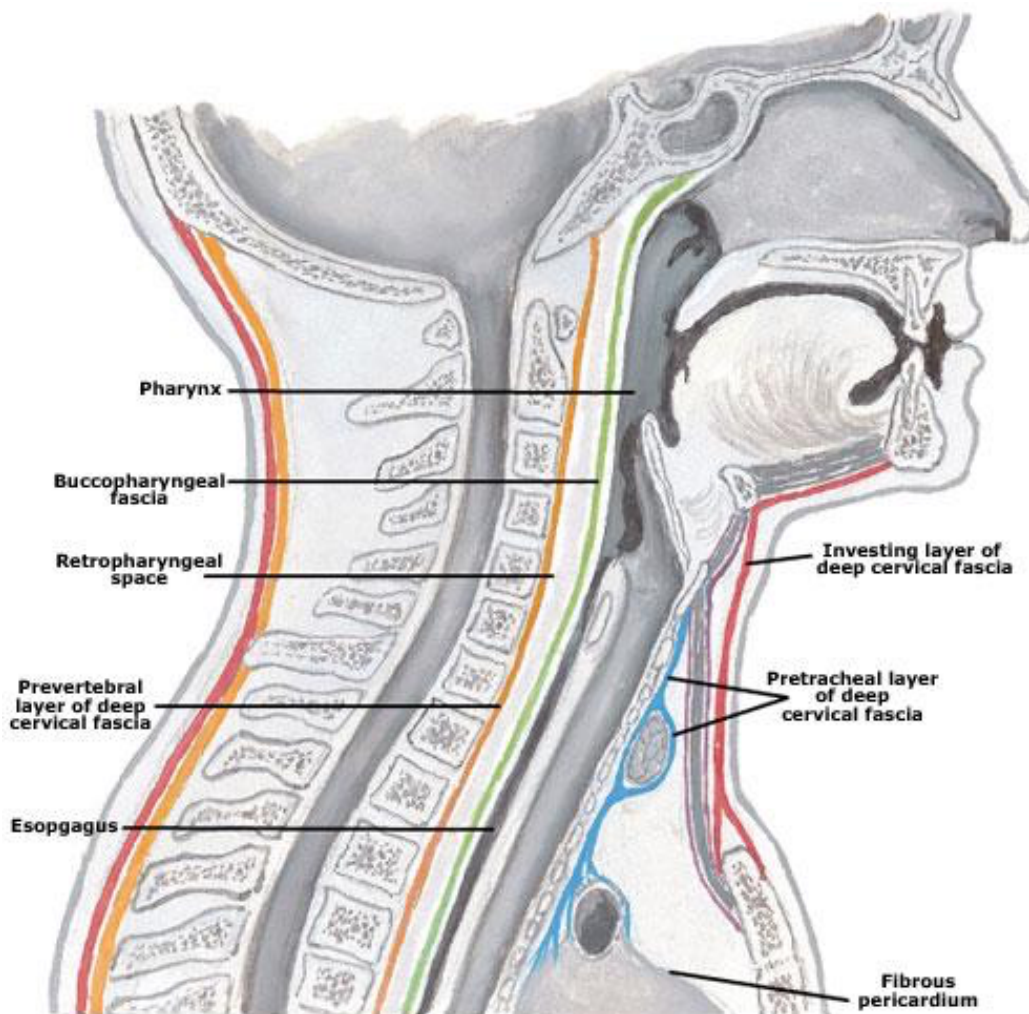
Depending on the literature the number of deep neck spaces varies from 6 to 12. They can be divided into the parapharyngeal space, the retropharyngeal space, the prevertebral space, the masticator space, the sublingual space, and the submandibular space (5). Some articles add six more spaces to the list. These spaces are the danger space, the carotid space, the pretracheal space, the peritonsillar space, the parotid space and the temporal space (11). The retropharyngeal space lies on the posteromedial side of the parapharyngeal space. It is anteriorly lined by the pharynx and esophagus and posteriorly by the vertebrae. This is the location of the retropharyngeal lymph nodes of Rouvière.

The anatomy of the parapharyngeal space (Picture 1), the retropharyngeal space (Picture 2) and the fascias of the neck (Picture 3) is presented in the following images.

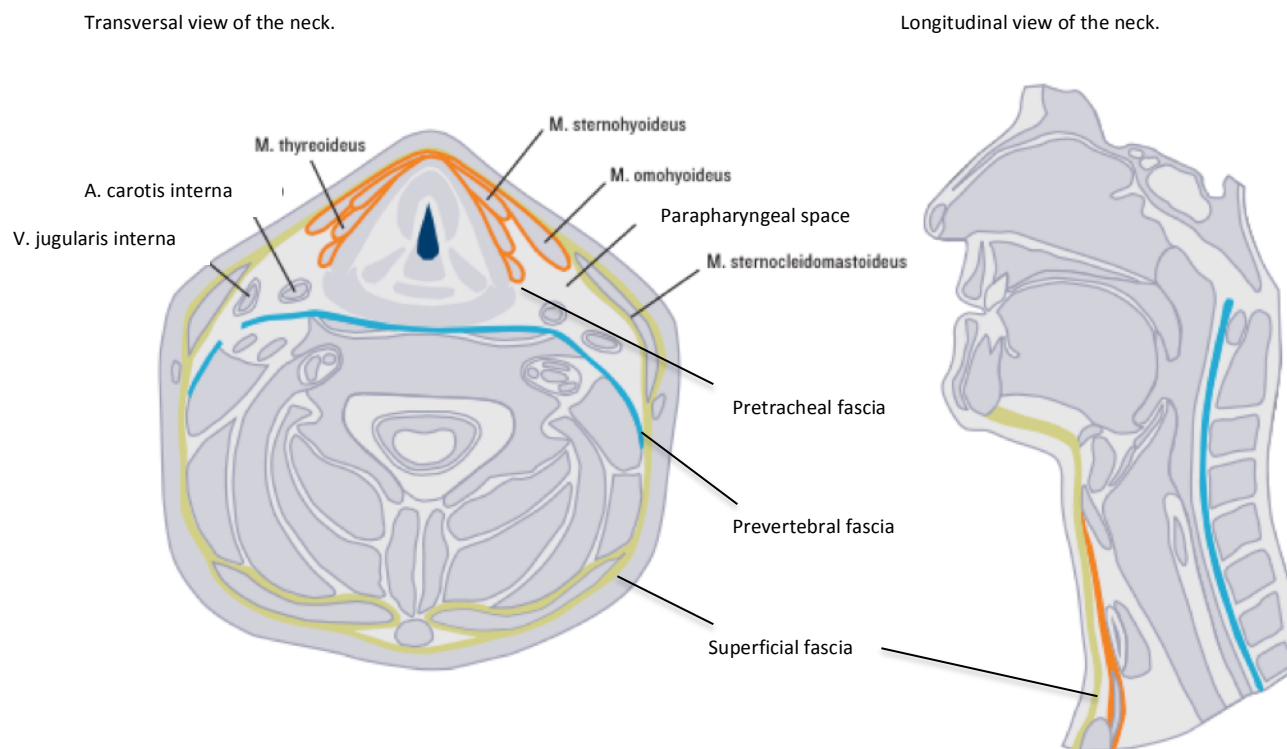


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Picture 1. The parapharyngeal space and close-by structures. (McGraw-Hills Access Surgery)



Picture 2. The retropharyngeal space and close-by structures. (<https://www.studyblue.com/notes/n/block-2-clinical-correlates/deck/3439918>)



Picture 3. A transversal and longitudinal view of the fascias of the neck. (5)

2.1.2 Epidemiology

Pediatric deep neck infections (DNI) are not totally uncommon and are characterized by a potentially life-threatening clinical course (3,4,12,13). The incidence of pediatric deep neck infections seems to be rising. Even a tenfold increase in incidence has been noted during the last decades (13) (14). One of the reasons Pelaz et al. initially did their study was a sudden appearance of 7 cases of pediatric DNIs during a 6-month period compared to none during the previous 4 years (15). The reason to this rise of incidence is not exactly clear (14,16,17). Some link it to a concomitant rise of incidence of more resistant microbes as well as the advent and wider accessibility of advanced diagnosing possibilities such as computed tomography and magnetic resonance imaging. The incidence was even higher though prior to the antibiotic era (18-21).

In 2014 Novis et al. published an article on a large group of pediatric deep neck infections ($N=41483$). The patients were treated in the US during a 10-year time period. The patient data was retrieved from a national database (KID – Kids's Inpatient Database) with the aim of defining whether the incidence of DNIs was on a rise or not. The results showed a clear rise in incidence of

retropharyngeal abscesses (RPA's) (from 0.10 to 0.22 / 10000). This was, however, not noted when all DNIs including peritonsillar abscesses were grouped together. During this time period the amount of operatively treated patients also diminished as conservative treatment became more popular. (17)

Due to the anatomic development of the head and neck region, parapharyngeal and retropharyngeal infections are more common among younger children. According to international studies the most common age of presentation is around 3 to 6 years (2,4,14,22,23). There are some possible reasons to this. Firstly, the lymphatic system is on a constant change in toddlers. The lymph nodes that are typically affected in retropharyngeal or parapharyngeal abscesses usually begin atrophying and diminishing after the age of 5. Secondly, the immune system is not fully developed in children, which might be one of the reasons that common pathogens cause abscesses more commonly in toddlers than adolescents. (3)

The manifestation seems to be highest during the winter months (3,4,24) which could be linked to the larger number of upper respiratory tract infections during this time. Multiple studies present a higher prevalence among boys than girls but no clear explanation to this has been found in the literature (1,2,7,22,23). Duval et al. also noted that the likelihood to acquire retropharyngeal or parapharyngeal abscesses rose with prior adenotonsillectomy (7).

2.1.3 Etiology

Pediatric deep neck infections are commonly preceded by a prodromal upper respiratory tract infection including pharyngitis, tonsillitis or lymphadenitis (1,3,25). Lymphadenitis may be a precursor of cellulitis and cellulitis as well as phlegmon may mature and form an abscess (7). In 2006 Abdel-Haq et al. reported that 97% of the patients in the study suffered from tonsillitis or pharyngitis and 87% of lymphadenitis (20). A pediatric abscess is very rarely caused by direct trauma of the head or neck (26,27). However, Daya et al. noted that a total of 30% of patients did not have any history of a preceding illness (28). Abscesses in general are usually preceded by a bacterial infection or a viral infection. They might present with no microbial growth (29), which is most likely explained by a prior use of oral antibiotics.

2.2 Findings

2.2.1 Symptoms

In terms of symptoms and clinical findings pediatric deep neck infections can be difficult to diagnose. Diagnosing difficulties arise because the symptoms are relatively un-specific and may mimic other illnesses. Clinical conditions such as epiglottitis, tonsillitis, pharyngitis and infection induced lymphadenitis or lymphadenopathy may present with similar symptoms (30,31). Craig et al. compared the clinical presentation of retropharyngeal abscesses to the clinical presentation of meningitis (32). Cellulitis, which usually is the earlier stage of an abscess, is one of the more difficult differential diagnoses for DNIs (33).

According to the Merck Manual of Diagnosis and Therapy pediatric patients with an RPA may present with "odynophagia, dysphagia, fever, cervical lymphadenopathy, nuchal rigidity, stridor, dyspnea, snoring or noisy breathing, and torticollis". The Merck Manual reports slightly different symptoms for parapharyngeal abscesses (PPA) than retropharyngeal abscesses. An anterior PPA may present with trismus and swelling around the area of the mandibular angle. Posterior PPAs however mimic RPAs and trismus is rarely present.

Pediatric patients presenting with DNIs are usually very ill and pain provoked (neck pain). This makes the estimation of the status more difficult. Pain may also present in the form of pharyngalgia, odynophagia or dysphagia (3,13,14,22,27,30,34). Most of the studies report fever as the most common symptom (63-100%) closely followed by reduced neck movements or torticollis and cervical lymphadenopathy (1,2,4,6,13,32,35). Reduced neck movements seem to be a little more common than torticollis (3,32).

During the past decade trismus has not been a very consistent feature in the literature with a prevalence of 8-17% (2,15,23,28). Wong et al. did not detect trismus at all (19). The prevalence of breathing problems has been even lower with only 2-7% of the patients presenting with stridor (2,23,28,36). A Turkish study from 2014 presented a higher percentage though (24%) which is similar to results (23%) from the end of the 1980s (27,35).

Historically considered the list of symptoms has not varied very much. In 1939 Manuel Grodinsky did an extensive overview study on retropharyngeal and parapharyngeal abscesses. He found that the symptoms were a high fever (ad 40 °C), neck stiffness, edema, swallowing problems and pharyngalgia. A rather interesting feature was the presence of a nasal voice, which does not come up in more recent literature. (37)

Pediatric deep neck abscesses may cause secondary symptoms, too, due to their localization close to major structures of the neck such as blood vessels or nerves. These symptoms are, however, caused by direct pressure against the structures and they are not symptoms of the abscesses per se.

2.2.2 Signs

Majority of the patients present with either reduced neck movements or torticollis. Quite interestingly Thomason et al. only reported a 9% finding of reduced neck movements in their patient material ($N = 245$) (38). Contrary to these findings Hoffmann et al. ($N=101$) found that 86% of the patients presented with reduced neck movements or torticollis (2). One difference to be noted is that Thomason et al. observed deep neck abscesses in general whereas Hoffmann et al. focused on parapharyngeal and retropharyngeal abscesses specifically. Torticollis is an important sign to be remembered – according to Pelaz et al. it is "the most important symptom to get early diagnoses to avoid complications" (15).

Neck edema and cervical lymphadenopathy are also common (21,22,39). In an American study that compared the clinical course of simple and more complex pediatric deep neck infections it was noted that decreased neck movements, neck edema, pharyngalgia and airway obstruction were more consistently present among patients that had a complex clinical course (13). In earlier transcripts bulging of the lateral pharyngeal wall was also listed as a sign of pediatric retropharyngeal (RPA) and parapharyngeal (PPA) abscesses (31,35,37). In more recent literature, however, it is not a very common finding (40).

Since deep neck abscesses might be difficult to differentiate from cellulitis it is interesting to note whether any difference in symptoms or signs may be distinguished. In 1997 Nagy et al. reported that patients with an abscess had fever, cervical adenopathy and pharyngeal bulging more frequently (33). In the Epidemiology - section it was notified that RPAs and PPAs are more

common among patients below the age of 5. The symptoms appear to be similar for pediatric and adult patients. Fever and neck mass are often present regardless of the age of the patient. However, the occurrence of lymphadenopathy decreases with an older age whereas neck stiffness becomes more common (41).

2.3 Diagnostics

2.3.1 Radiology / Imaging

Due to the variety of symptoms and clinical signs radiological imaging is an essential part of the diagnosis of pediatric deep neck infections. The advent of efficacious radiological imaging such as magnetic resonance imaging (MRI), computed tomography (CT) and contrast enhanced computed tomography (CECT) has provided a new means of diagnostics. Earlier, before the wide-spread use of computed tomography, ultrasound (US) and lateral neck radiographs were the foremost means of imaging.

Computed tomography has been widely used to diagnose abscesses of the neck. In three studies from the shift of the 1990s and 2000s the positive predictive value (PPV) of CT scans was found to be between 40-83%. The negative predictive value (NPV) was between 53%-100% (23,42,43). In the same studies the sensitivity of the CT scan was between 45-91% and the specificity between 60-100% (42,43). In 1999 Stone et al. did a research in which all patients underwent a CT scan and an explorative operation. In 73.5% of the cases the CT diagnosis of an abscess was found accurate during surgical intervention. The false positive rate was 11.8% and the false negative rate was 14.7%, which are relatively low (44).

Suggestions have also been made concerning the diagnosis of abscesses on CT scans. Freling et al. suggested identification of an abscess based on the presence of abnormal collections of air or large collections of fluid (>3.5 cm in diameter) whereas Miller et al. mostly spoke of discrete hypodensities (25,45). Malloy et al. interestingly did not recognize any correlation between surgical drainage results and rim enhancement, abscess size or prevertebral soft tissue thickness. Therefore, their conclusion was that no certain CT characteristics predictive of surgical drainage could be found. (46) Smith et al. tried to investigate whether it would be possible to differentiate an abscess from a phlegmon based on a specific spectrum of Hounsfield units. They did not find statistically

valid results. (47) A Hounsfield unit is numeric information used to define tissue density on CT scans. Meyer et al. came to the conclusion that all susceptible patients should undergo a CT scan regardless of symptom duration (22).

Ultrasound imaging is another imaging modality used in defining the presence of deep neck abscesses. Kalmovich et al. reported results that show a sensitivity and PPV of 33% and 50% respectively for ultrasound imaging. In the same study CT had a sensitivity of 58.3% (for an abscess wall). The problem seems to be the difficult diagnosis between phlegmon and abscess on an ultrasound scan (48). US may however be a useful complimentary tool during surgical drainage (49).

The diagnostic criteria for abscesses on lateral neck radiographs were rather vague. According to Lee et al. the presence of an abscess was determined based on the bulging of the retropharyngeal or retrotracheal spaces. It is noteworthy that this bulging also occurs during expiration and normal flexion of the neck. Since the imaging is done on pediatric patients this is a rather big cause of unreliability. (31)

2.3.2 Microbiology

As earlier mentioned pediatric deep neck infections (DNIs) are generally caused by an upper respiratory tract infection or less commonly by a dental infection. The microbiological cultures mostly consist of oropharyngeal and nasopharyngeal pathogens and the flora is rich in variety consisting of over 300 anaerobic and aerobic species. The foremost microbes represented are those of the oropharyngeal area and maybe even microbes from the skin area (35,41). *Streptococcus pyogenes*, *Staphylococcus aureus* and *Haemophilus influenzae* are mentioned among the most common aerobic pathogens whereas anaerobic species such as *Prevotella* or *Fusobacterium* remain more uncommon (35,50).

It is usually possible to isolate multiple organisms from an abscess. The infections may be polymicrobial or caused by a single or two organisms (14,18,51). However, despite the presence of pus at surgery, it is not always possible to isolate any bacterial growth from an abscess. The rate of positive pus cultures varies from one study to the other and some present values as low as 46-61% (2,12,19) whereas others report percentages as high as 79-97% (14,18).

A shift has been seen in the microbiological spectrum of pediatric DNI's. In almost all recent literature the culture results show a higher incidence of *Staphylococcus aureus* than *Streptococcus pyogenes* (12,38,51,52). Earlier studies showed a predominance of *Streptococcus species*, and most typically *Streptococcus pyogenes* (28,32,33). Some recent literature still shows a highest incidence of *Streptococcus pyogenes* (2,4,19). Abdel-Haq et al. published two separate articles on the microbiology of pediatric deep neck infections. In 2006 *Streptococcus viridans* was the most commonly isolated organism whereas concern was made for the rising incidence of *group A beta hemolytic streptococcus* (GAHBS, *Streptococcus pyogenes*) (20). In 2012 in contrast awareness was risen to the rising incidence of *Staphylococcus aureus* and its more resistant form methicillin-resistant *Staphylococcus aureus* (MRSA) (51).

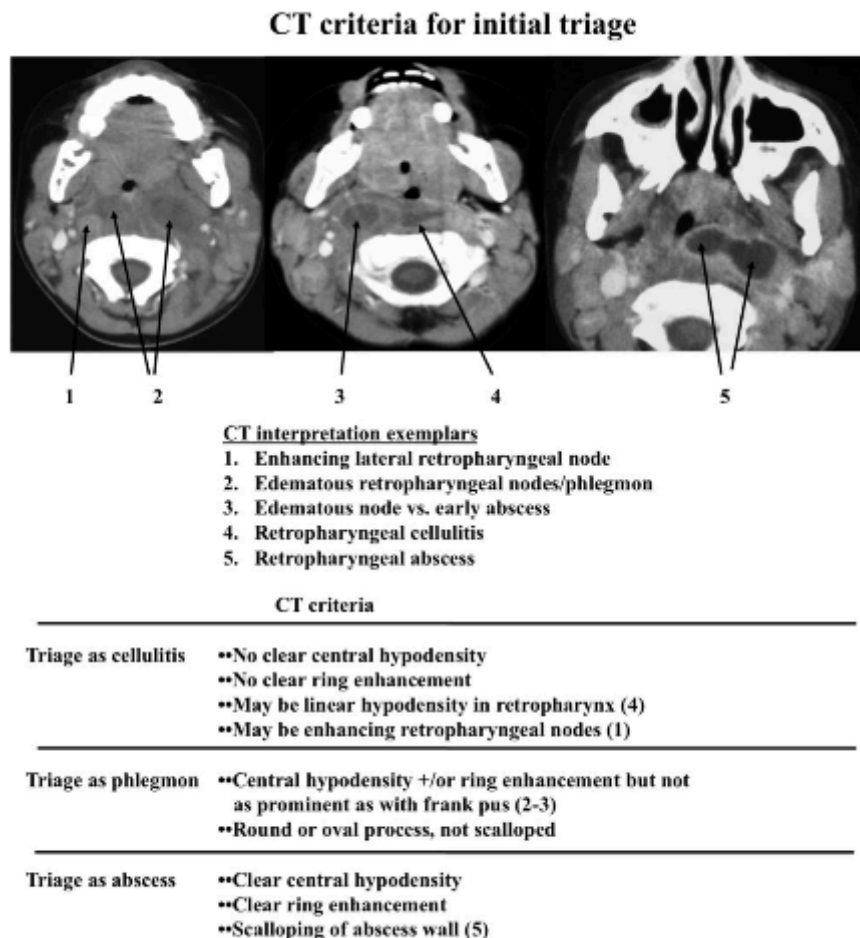
Several studies compared the susceptibility of the *Staphylococcus aureus* species to antibiotics during two adjacent time periods. They all noticed a striking rise in the incidence of MRSA going from a prevalence of 0% up to 24-34% (53-55). MRSA does not pose a problem only because it is more resistant to its nature but also because it seems to be more prone to cause complications. During the same time-period that Wright et al. noted a risen incidence of MRSA infections, the number of RPA (retropharyngeal abscess) caused mediastinitis rose. Other complications linked to MRSA infections were bacteremia and the need for re-drainage, ICU treatment or intubation (38,52). Children suffering from MRSA caused DNIs also tend to be younger in age (<2 years) (1,56). However, the methicillin-resistant *Staphylococcus aureus* isolated from pediatric DNIs is thought to be community-acquired (CA-MRSA) in nature which is in contrast to the infections received from a hospital-environment. CA-MRSA is genetically different from hospital-based MRSA and also less resistant to antibiotics (51,52,55).

2.4 Treatment

Throughout the years there has been wide discussion on the preferred choice of treatment for pediatric deep neck infections. Historically, up until the advent of antibiotics in the 1940s, pediatric deep neck abscesses were treated surgically. The discussion focused on whether an external i.e. open surgery or transoral approach should be chosen (37). After antibiotics became more common penicillin and penicillin-type drugs were used (35). Now, the discussion focuses on whether a

conservative or operative approach should be chosen. Depending on the article the preferences vary and no clear consensus has been reached.

The attempt to produce treatment guidelines has not been very effective. The problem raised by many studies is the retrospective nature of the research (26). Due to the lack of clear-cut guidelines the choice of treatment is dependable on the ear-, nose- and throat specialist seeing the patient (2). Therefore attempts at composing treatment protocols for pediatric deep neck infections have been made (4,6). Saluja et al. created CT criteria and a management algorithm (per oral or parenteral antibiotics or surgery) as shown in Picture 4 based on the CT findings in order to standardize management (6). Johnston et al. also made an attempt to produce a treatment protocol for retropharyngeal abscesses as seen on Picture 5 (4). The results were rather disappointing, though, as no treatment guidelines could be composed.



Picture 4. Computed tomography (CT) criteria for initial triage of patient as having either cellulitis, phlegmon, or abscess. (6)

Bolton et al. ($N=130$) and Cheng et al. focused on the conservative treatment of DNIs. Bolton et al. focused on signs suggestive of successful medical treatment whereas Cheng et al. searched for clinical markers linked to unsuccessful medical treatment. The results were fairly similar. An abscess size of 22 mm or less were predictive for a successful medical trial. An older age at presentation was also statistically significant and suggestive for successful medical treatment in both of the studies (>15 months). (2,57) Two more recent studies made in Italy and Turkey did not find any difference between the ages of the patients undergoing surgery or medical treatment. The Turkish study reported a good outcome for both of the groups. (27,30)

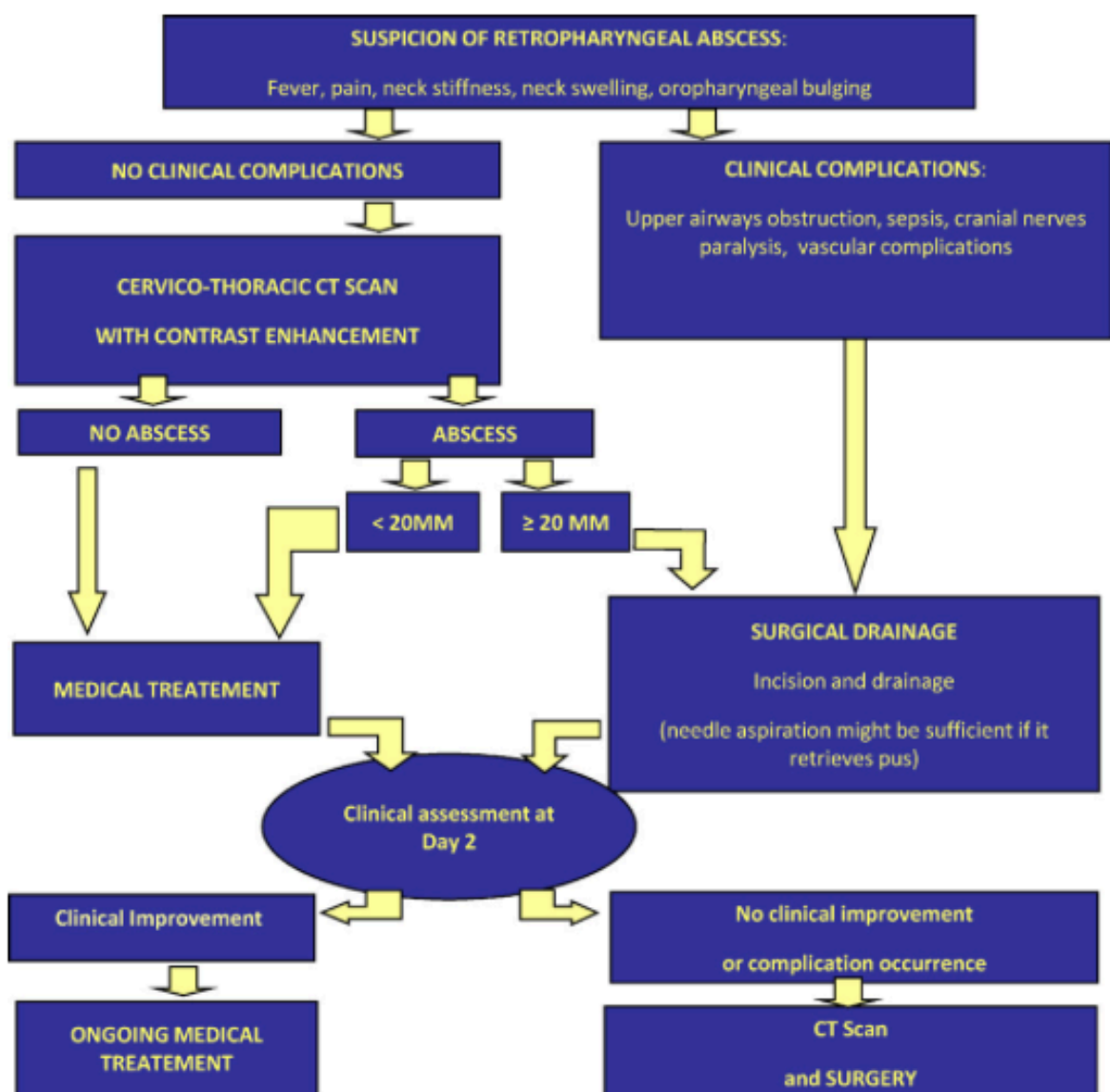


Fig. 3. Treatment protocol.

Picture 5. Treatmen protocol of children with suspected retropharyngeal abscess. (4)

Page et al. did a retrospective chart review on 162 patients with retropharyngeal abscesses. Their research group noticed that out of 36 conservatively treated patients a total of 17 patients (47%) required late surgical intervention which is quite a large percentage. The predictive factors for successful surgical drainage were a symptom duration of 48 hours or more, an abscess diameter of > 20mm and antibiotic treatment prior to the hospitalization. (14) It could be suggested that the criteria seem quite logical – a longer duration of symptoms as well as a need for prior antibiotic treatment are suggestive of a more complicated clinical course per se.

Neither the length of the hospital stay nor the risk for complications seem to be drastically affected by the choice of treatment (2,4,58). Some report a slightly longer duration (1) of the hospital stay for conservatively treated patients whereas others note no difference (3). Thus it seems that it would be possible to wait for the initial response of the illness to conservative treatment before proceeding to surgery. If, however, an operation would be essential for the healing process, the length of the hospital stay would not be unnecessarily lengthened (2,4,59).

Carbone et al. reviewed eight retrospective studies that covered the conservative treatment of pediatric DNIs. Due to the retrospective nature of the studies an insufficient strength of evidence was noted and no conclusion could be drawn about the indications for medical treatment (26). Wong et al. however did a case-control study where treatment groups were divided according to the abscess size. Of those who had an abscess of less than 25 mm, 10 out of 27 conservatively treated patients required surgical opening of the abscess after a 24-h follow-up. They were clearly younger in age (3.66 years.) compared to those who avoided surgical intervention (5.7 years). The patients that had an abscess of more than 25 mm were on average 4.49 years in age and primarily underwent surgical intervention. (19)

In 2001 Kirse et al. made the claim that patients should be treated surgically due to the risk of growth and rupture of the abscess and therefore a higher risk of complications. With surgical intervention the duration of antibiotic treatment remained shorter, too (36). More recent studies, though, have noticed that the risk of complications and the length of the hospital stay does not seem to be affected by the choice of treatment.

In the end the clinical picture should be decisive for the choice of treatment. Any signs of an unstable condition, such as respiratory distress or even torticollis, should be evaluated to assess the need for operative treatment (15,30,32). If a surgical approach is chosen the decision of transoral

versus external approach to the abscess is made based on the localization of the abscess in relation to the oral cavity and the great vessels of the neck (36). When a medical approach is chosen, the antibiotics should be chosen based on the sensitivity of the causative pathogens. The pathogens are usually those of the normal flora of the oral cavity or the airways.

2.5 Complications

Deep neck infections are potentially life-threatening and thus should be recognized. The possible life-threatening complications include airway obstruction, mediastinitis, septic shock, abscess rupture, jugular thrombosis or aneurysm of the carotid artery (1,7). Cheng et al. ($N=178$) published results where the main complications (12/178, 9%) were a need for re-drainage (5/12), readmission for IV antibiotic therapy (3/12) and sepsis (2/12). Life-threatening complications arose in only 2.2% of the cases. (1) Historically pediatric DNI's have been characterized by significant morbidity and mortality (14).

Baldassari et al. ($N=245$) did a retrospective study to focus on the complications of pediatric deep space neck abscesses. The likelihood of complications was higher for RPAs than other abscesses. A younger age as well as the presence of *Staphylococcus aureus* in the pus cultures did raise the incidence. The complications were mainly mediastinitis ($N=9$) and a need for intubation ($N=8$). (16) Daya Hamid et al. also noted a younger mean age in the group of patients that suffered from complications (28). In 2003 Wang et al. ($N=196$) highlighted characteristics of life-threatening infections. The study did, however, not separate between pediatric and adult patients. In this study 7.7% of the patients had complications such as the ones mentioned above (airway obstruction, mediastinitis, jugular vein thrombosis). (21)

Mediastinitis is one of the dreaded complications of retropharyngeal abscesses as there is no border limiting the spread between the retropharyngeal space and the mediastinum. The association between mediastinitis and methicillin-resistant *Staphylococcus aureus* has been investigated (52,60). It does seem that the rise of incidence of mediastinitis might be linked to a rising incidence of MRSA (60). Not all research, however, shares the notion of a connection between the microbiological spectrum and a more complicated clinical course (13).

Due to the development of efficient imaging and effective antimicrobial treatment, the life-threatening complications remain rare and the treating results of deep neck infections are generally successful. The rate of complications remains low (4.4%-9.4%) (16,28,38,51). The highest rate of complications (9.4%) was noted in group of patients that included a high "urban and immigrant population" (16). In 1988 Thompson et al. reported an astonishingly high percentage of complications (19/65, 29%). They, however, included pneumonia ($N=5$) in the results which does raise the percentage from 22% to 29%. (38) The rate is still considerably higher than the rate in more recent study.

2.6 Outcome

The treatment outcome for pediatric deep neck infections is fairly good based on the relatively low rate of complications. The literature suggests that children rarely present with the same illness at a later time (2,30,61). The outcome can be evaluated based on different treatment subgroups (i.e. immediate surgical drainage, delayed surgical drainage, and treatment with medical therapy alone (1)). Historically the outcome has improved after the advent of efficient antibiotics, accurate imaging and early detection (14).

Saluja et al. (2013) did not find support to the claim that immediate drainage of the abscess would secure a better outcome (6). It does seem that first line medical treatment in well chosen patients is effective and does not affect the outcome negatively (3,4,15,62). When Hoffmann et al. defined whether the outcome of medical treatment was affected by age, symptom duration or leukocyte count no influence was found (2).

3 AIMS OF THE THESIS

Even though the clinical picture of pediatric deep neck infections is rather clear (though sometimes difficult to distinguish) the choice of treatment still remains a challenge. There are no previous studies on pediatric deep neck infections in Finland. Also, there is a lack of clear treatment guidelines for pediatric deep neck infections.

Therefore, the primary aim of the study was to define the clinical picture and abscess characteristics as well as the treatment outcome of pediatric deep neck infections in a Finnish patient series. It was of interest to observe whether certain clinical characteristics or factors would be predictive of successful medical or surgical treatment. Realizing the limitations of a retrospective chart review and a relatively low amount of patients the wish was to report of any characteristics suggestive of a need of either conservative or operative treatment.

The Helsinki University Hospital (HUU) referral area currently covers an area of 1.6 M people, which is approximately one third of the total population in Finland. Therefore, we were able to perform an epidemiological investigation of this disease entity.

The aim of this study was to define the characteristics, treatment and outcome of pediatric deep neck infections in the parapharyngeal, the retropharyngeal and the jugulodigastric chain of lymph nodes.

4 MATERIALS AND METHODS

4.1 Materials

The study cohort included 62 pediatric patients between the ages of 0 to 16 years. The patient series was identified from the Helsinki University Hospital (HUH) patient databases throughout a 10-year study period (01.01.2001-31.12.2010). The patients were admitted to the Department of Otolaryngology – Head and Neck Surgery primarily with a letter of referral from outpatient clinics but also directly from regional hospitals or more rarely from the Children's Hospital at HUH. The laboratory results and culture results were retrieved from the laboratory database of the Hospital District of Helsinki and Uusimaa (HUSLAB). The upper age limit was set at 16 years since this is the upper age limit for pediatric patients at the Children's Hospital.

The selection was made on the base of diagnostic codes and operation codes present on the patient charts. These specific codes were J39.0 ("Retropharyngeal and parapharyngeal abscess"), J39.1 ("Other abscess of pharynx"), L02.1 ("Cutaneous abscess, furuncle and carbuncle of neck") and ENA32 ("Incision of deep pharyngeal infection"). The material included medical reports, surgery reports and roentgen reports from visits at the Emergency Outpatient Clinic and Scheduled Appointment Clinics for Ear, Nose and Throat (ENT) Diseases as well as records of inpatient care at the ENT ward.

A total of 88 patients originally filled these criteria. 26 patients were excluded due to different reasons. Eleven out of 26 patients had a clinically susceptible finding that pointed towards an abscess. However, all except one had radiological imaging performed and no abscesses were found (lymphadenitis $N=7$, cellulitis $N=2$, lymphadenopathy $N=2$). Three out of 26 patients were outpatients and only needed an ENT consultation. Four out of 26 patients had a superficial abscess that originated from the skin or other superficial parts of the head or neck. Four patients had an auricular abscess (retroauricular $n=2$, preauricular $n=1$, periauricular $n=1$) and three patients had an infected cyst of the thyroglossal duct. One patient had a "cold abscess" – an atypical mycobacterial infection – and was excluded from the research group. The study was performed on the remaining 62 patients with an abscess in one of the deep neck spaces.

4.2 Methods

This study was performed as a retrospective chart review. Patient records of the 62 patients were reviewed and the following variables were collected. The demographic data (age, sex, underlying diseases and underlying medications) and the status prior to the arrival at the hospital (prodromal illness and duration of fever) were checked. The clinical status of the patient as well as the clinical findings at the arrival at the hospital (fever, pharyngalgia, difficulty swallowing, drooling, trismus, irritability, neck edema, cervical lymphadenopathy, reduced neck movements and torticollis) were checked. The choice of imaging modality (ultra sound, computer tomography, magnetic resonance imaging or other) was collected. The choice of treatment was reported according to one of four subgroups – 1) medical treatment alone, 2) first line surgical intervention, 3) an early medical trial and a late surgical intervention and 4) an early surgical intervention and a late surgical intervention. The presence of pus, the microbiological culture results, the rate of complications as well as the general treatment outcome were also registered as was the length of the hospital stay.

An institutional research approval was granted for the study (02.10.2013).

5 RESULTS

A majority of the patients were boys (57%, $N=35$). The mean age was 7.1 years (median 5.7 years, 0.3-15.9 years). Ten patients had an underlying disease (asthma / infectious asthma (4), muscular VSD (2), depression (1), prolonged QT-time (1), multiple diagnoses (2)). Most of the abscesses were located in the jugulodigastric area followed by those in the parapharyngeal and the retropharyngeal spaces. The demographic data, symptoms and clinical findings as well as treatment and outcome across various abscess localizations are presented in Table 1.

	Parapharyngeal	Retropharyngeal	Jugulodigastric	Other
N	18	7	32	5
Age, years	8.4	8.3	6.1	7.1
Symptoms, %				
Fever	89 (16/18)	100 (7/7)	56 (18/32)	80 (4/5)
Pharyngalgia	72 (13/18)	100 (7/7)	31 (10/32)	80 (4/5)
Difficulty swallowing	61 (11/18)	43 (3/7)	25 (8/32)	0
Trismus	33 (6/18)	29 (7/7)	9 (3/32)	20 (1/5)
Drooling	6 (1/18)	29 (2/7)	0	0
Irritability	67 (12/18)	43 (3/7)	31 (10/32)	80 (4/5)
Neck edema	72 (13/18)	71 (5/7)	94 (30/32)	100 (5/5)
Reduced neck movements	61 (11/18)	71 (5/7)	22 (7/32)	80 (4/5)
Torticollis	22 (4/18)	43 (3/7)	6 (2/32)	20 (1/5)
Cervical lymphadenopathy	94 (17/18)	71 (5/7)	50 (16/32)	80 (4/5)
Duration of fever prior to hospitalization	2,7 (0-7) *	3,3 (0-7)	2,5 (0-14) **	3,8 (0-7)
CRP count, mean	158 (33-303)	146 (41-230)	73 (9-323)	202 (34-429)
Size of abscess, mm (range) *	27,5 (15-50)	37,0 (20-80)	29,4 (17-70)	21,7 (15-25)
Presence of pus				
Treatment, %				
a)	16,5 (3/18)	29 (2/7)	9 (3/32)	20 (1/5)
b)	39 (7/18)	71 (5/7)	44 (14/32)	40 (2/5)
c)	28 (5/18)	0	38 (12/32)	40 (2/5)
d)	16,5 (3/18)	0	9 (3/32)	0
Surgical intervention, %				
Aspiration only	11 (2/18)	0	28 (9/32)	0
Transoral	67 (12/18)	71 (5/7)	9 (3/32)	40 (2/5)
External	11 (2/18)	14 (1/7)	50 (16/32)	40 (2/5)
Tonsillectomy	50 (9/18)	57 (4/7)	3 (1/32)	60 (3/5)
Re-surgery	17 (3/18)	0	25 (8/32)	20 (1/5)
Complications, % (N)	22 (4/18)	29 (2/7)	0	0
Hospital stay, days	4,8 (1-7)	3,9 (1-10)	4,5 (0-11)	6,6 (3-16) ****

* 3/18 report of fever missing ** 1/32 report of fever missing *** 5/18 report of abscess size missing

**** Length of hospital stay 4,3 days, when patient with longest hospital stay excluded

Treatment: a) Medical treatment only b) Early surgical intervention

c) Early medical treatment and late surgical intervention d) Early and late surgical intervention

Table 1. Patient characteristics based on the location of the abscess.

The jugulodigastric abscesses were positioned along the sternocleid muscle or the mandibular angle ($N=19$), close to the submandibular ($N=6$) or parotid salivary glands ($N=2$) or in the area of lateral neck cysts ($N=5$). The group named "Other" represents findings that showed an abscess in the radiological imaging but were eventually not true abscesses. One of these patients ended up having epiglottitis even though the symptoms were suggestive of a DNI.

For symptoms and clinical findings at presentation see Figure 1. Nearly half of the patients were irritable (47%) which presented as tiredness, weepiness, or irascibility. Drooling (5%) was not a typical symptom and none of the 62 patients presented with breathing problems at the initial evaluation at the emergency room.

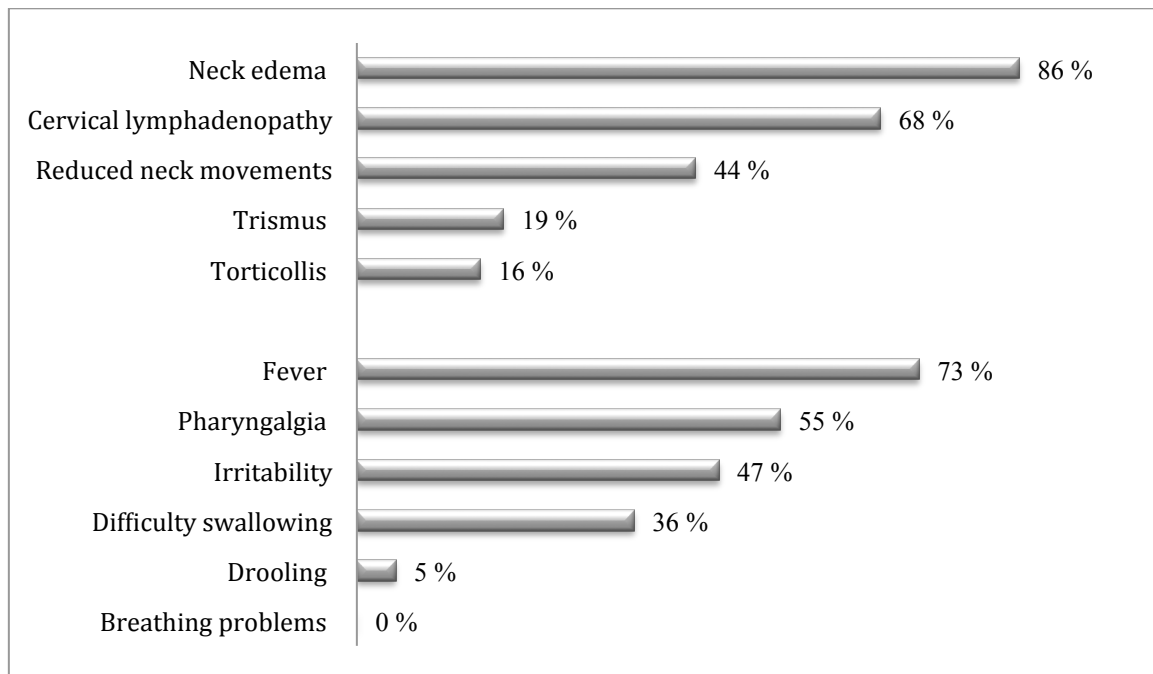


Figure 1. Symptoms and clinical signs

Nearly all patients underwent radiological imaging (60/62). Seven out of 60 patients had no abscess. Two patients had an early abscess on the radiograph. Ultrasound was the foremost means of imaging ($N=32$). Only 7 patients that underwent an US required further evaluation by computed tomography or magnetic resonance imaging. Twenty patients had an initial CT scan ($N=11$) or MRI ($N=9$) done. All of the MRI scans were done during the second half of the 10-year study period. No patients underwent a lateral neck radiograph. During the latter 5 years the amount of patients rose by 16 and US remained the foremost imaging modality.

In 36 of the 53 (68%) surgically treated patients an abscess was found both on the radiograph and during operation. Seven out of 53 (13%) radiological findings were false negatives as the radiograph showed no abscess but pus was found during incision. In addition 6 of the 53 (11%) cases were false positives as an abscess was seen on the radiograph but could not be found during incision. It should be noted, however, that no distinction was made between the imaging modalities (US compared to CT scan or MRI).

A clear majority of the patients underwent either primary or secondary surgical intervention (85%, $N=53$). The percentage of medically treated patients was higher during the first 5 years (22%) than the last 5 years (10%). Table B compares the demographic data, symptoms and clinical signs as well as treatment and outcome in the conservatively and surgically treated groups. Group B included three types of patients. Firstly, those who underwent initial surgical intervention upon arrival at the hospital ($N=28$). Secondly, patients that were initially treated with intravenous antibiotics (mean duration 2.6 days) but later required a surgical intervention ($N=19$). Thirdly, patients that underwent both early and late surgical intervention ($N=6$). See Figure 2 below.

Patient characteristics	Group A	Group B
Demographic data		
Number of patients	9	53
Sex N		
Male	5	30
Female	4	23
Age (median)	6.8 (2.6-15.7)	5.3 (0.32-15.9)
Symptoms % (N)		
Fever	67 (6/9)	74 (39/53)
Pharyngalgia	78 (7/9)	51 (27/53)
Irritability	67 (6/9)	43 (23/53)
Difficulty swallowing	33 (3/9)	36 (19/53)
Drooling	11 (1/9)	4 (2/53)
Clinical signs % (N)		
Neck edema	89 (8/9)	85 (45/53)
Cervical lymphadenopathy	78 (7/9)	66 (35/53)
Reduced neck movements	67 (6/9)	40 (21/53)
Trismus	22 (2/9)	19 (10/53)
Torticollis	11 (1/9)	17 (9/53)
Size of abscess mm	21.8 (15-30) *	31.1 (15-80) **
Duration of fever prior to hospitalization (days)	2.7 (0-7)	2.8 (0-14)
Per os antibiotic treatment prior to hospitalization % (yes)	78 (7/9)	62 (33/53)
Hospital stay (days)	3.9 (0-7)	5.0 (0-16)

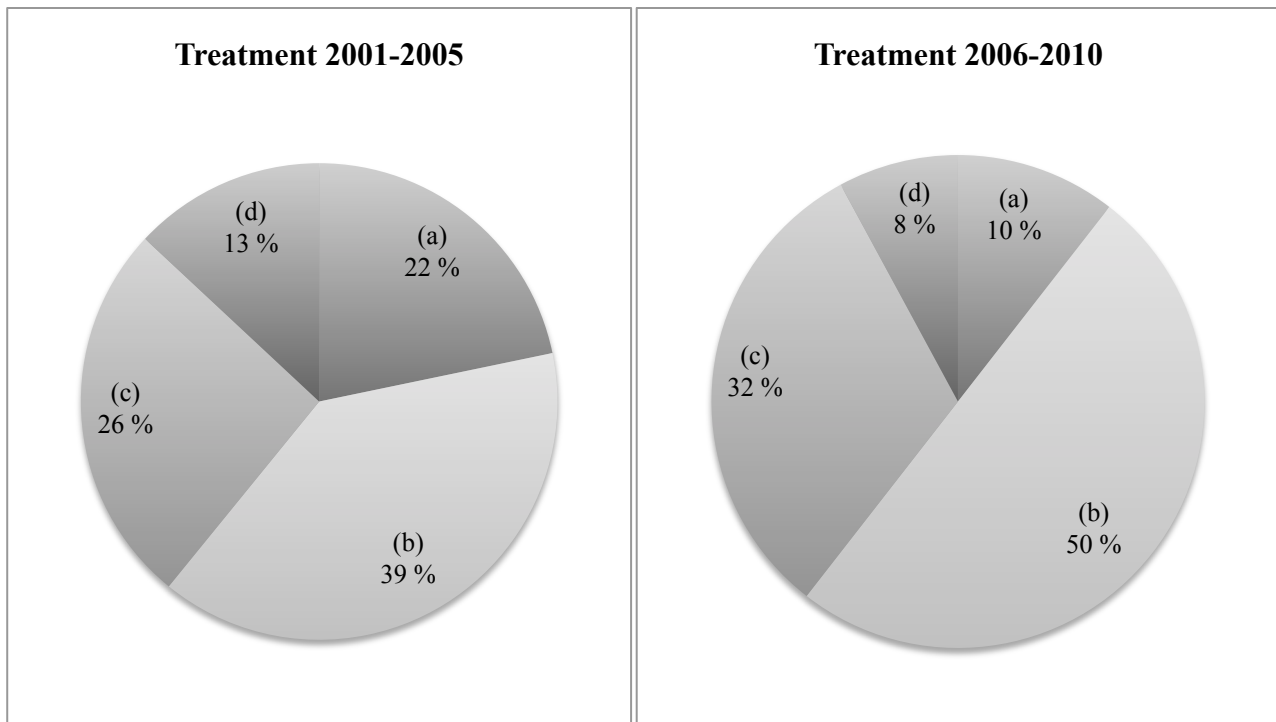
Group A Conservatively treated patients

Group B Operatively treated patients

* Missing from 1 out of 9 patients (diameter not (1))

** Missing from 17 out of 53 patients (missing radiological report (2), diameter not mentioned on the radiological report (5), no abscess on radiograph (8), radiological evaluation

Table 2. Patient characteristics based on the choice of treatment.



(a) Medical treatment alone (b) Early surgical intervention
(c) Early medical intervention and late surgical intervention (d) Early surgical intervention and late surgical intervention

Figure 2. Treatment modality.

Forty-six out of the 53 surgically treated patients had pus present at the surgical intervention (87%). The distribution of the bacterial cultures can be seen Figure 3. The most commonly detected pathogen was *Staphylococcus aureus* followed by *Streptococcus pyogenes*. None of the *Staphylococcus aureus* cultures showed methicillin-resistant *Staphylococcus aureus*. A majority of the cultures presented growth of one pathogen ($N=22$) or no growth at all ($N=12$). Three samples had growth of normal flora and in a total of six samples were polymicrobial.

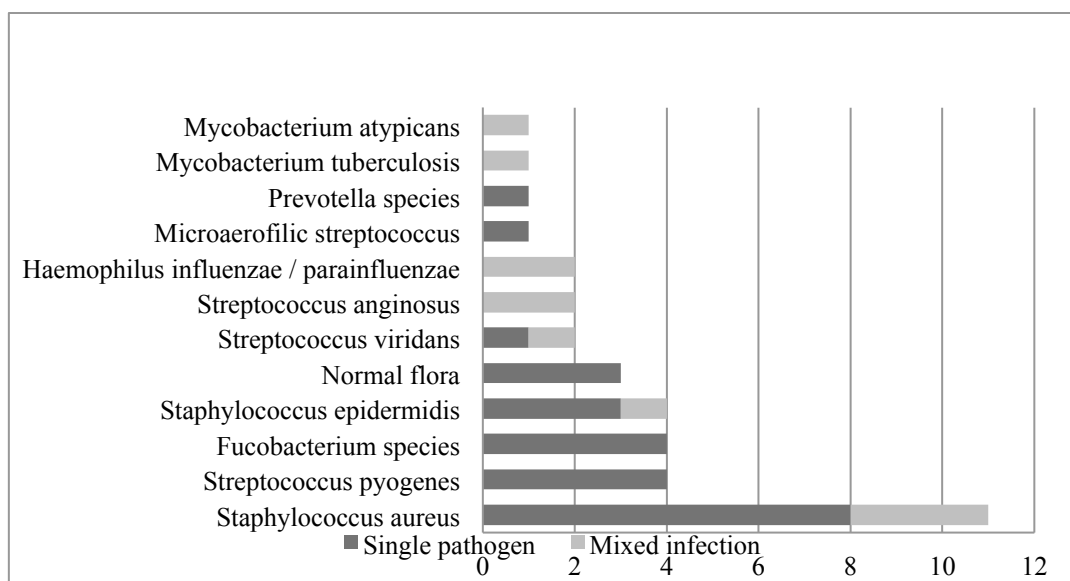


Figure 3. Microbiological culture results.

Six out of 62 patients had complications (9,6%). These were mediastinitis ($N=1$), pneumonia ($N=2$) and a need for intubation and ICU follow-up due to breathing problems ($N=3$). The abscesses were localized in the parapharyngeal ($N=4$) or retropharyngeal spaces ($N=2$). The mean age was 8.5 years. (4.9-14.2 years). Concerning the symptoms neck edema (100%), trismus (33%), torticollis (33%) and drooling (17%) were a little more common. The mean CRP count (189) was similar to that of RPAs and PPAs. The mean abscess size was larger 40.2 mm (21.0-80.0). The additional diagnoses noted were primarily those of congenital neck ducts or cysts ($N=5$) and 4 of these were electively removed at a later time. The patients were in the hospital for a mean of 6.7 days (3-10), which is a little longer than the other patients.

A small peak was seen in the number of pediatric deep neck infections in the fall months from September to October ($N=19$, 31%). Spring ($N=16$), summer ($N=14$) and winter ($N=13$) came closely after. The number of patients rose between 2006-2010 ($N=39$) compared to 2001-2005 ($N=23$) as seen of Figure 4. However, the change in patient population during this time period was not taken into account and therefore it is not possible to take a stand on the rise of incidence for pediatric deep neck infections in this population.

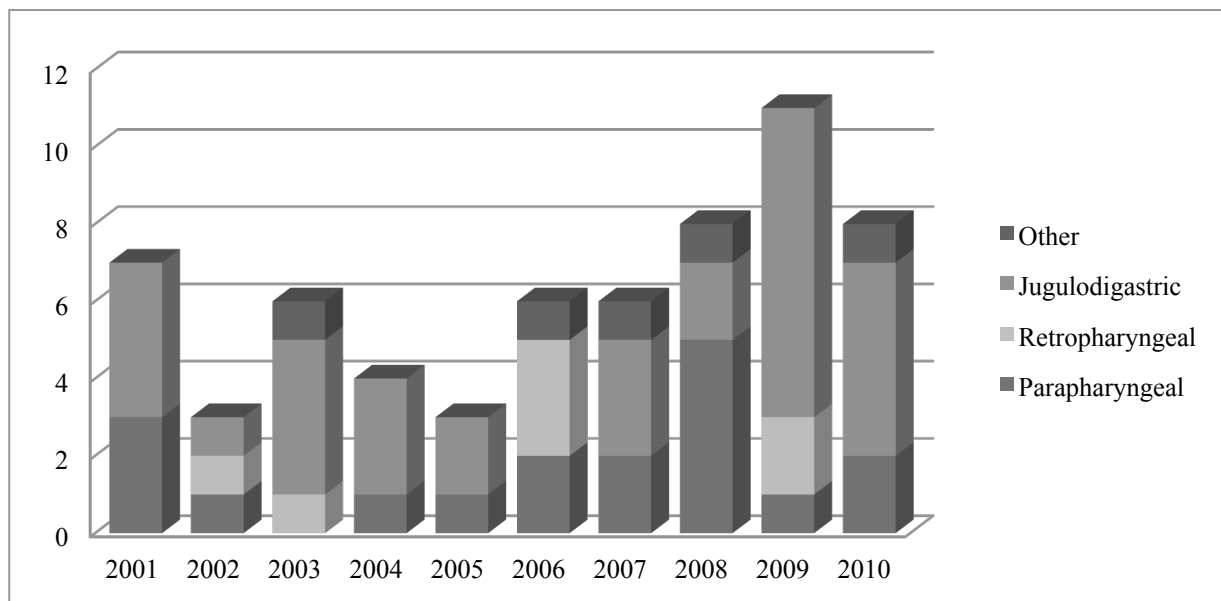


Figure 4. Yearly distribution of abscesses across the study period from 2001 to 2010.

6 DISCUSSION

Pediatric deep neck infections are potentially life-threatening complications of regular upper respiratory tract infections or dental infections that spread into the deep cavities of the neck. New international studies are frequently published on pediatric DNIs (6,30,63). The more recent studies have particularly focused on the choice of treatment (2,4,26,57). However, despite the internationally ongoing discussion there are no Finnish studies on the subject.

The aim of this study was to define the characteristics of the pediatric patients that presented with deep neck infections, or abscesses, at the Department of Otolaryngology – Head and Neck Surgery at the Helsinki University Hospital (HUU) during a 10-year time period. The original assumption was that conservative treatment had become more common throughout the years. One assumption was that the complications of pediatric deep neck infections were relatively uncommon. The focus was not set on merely parapharyngeal and retropharyngeal abscesses but abscesses of the jugulodigastric chain were also included in this study.

Despite the original assumption the results showed a preference for surgical intervention throughout the 10-year time period. It was even a little more common to treat patients surgically during the latter part of the 10-year study period (90% vs. 78%). The outcome of the treatment was good regardless of the treatment modality that was chosen. The length of hospital stay was not affected by the choice of treatment, which has been noted by other groups as well (2,5,58). Conservatively treated patients had a slightly shorter mean hospital stay (3.9 days) compared with the patients that were treated surgically (5.0 days). The median age of the patients that underwent surgical intervention (5.3 years) was lower than the median age of the patients that were treated conservatively (6.8 years). However, patients who were initially treated with intravenous antibiotics and later required surgical intervention had an even lower median age (4.4 years), which has been noted in another study too (19).

The mean age of all patients was a little higher than the one reported in the literature (7.1 years) and even a little higher for patients with parapharyngeal (8.3 years) and retropharyngeal (8.4 years) abscesses. It was noticed that when the abscess was located near the mandibular angle or around the proximal parts of the sternocleid muscle the mean age was lower (4.8 years). Since these abscesses mainly arise in necrotized lymph nodes it is possible that younger children acquire infections at these locations in an easier manner.

The symptoms in general were compatible with those reported in the literature with neck edema, fever, cervical lymphadenopathy, pharyngalgia and reduced neck movements being some of the most common symptoms (1-4,6). Trismus, reduced neck movements, torticollis and cervical lymphadenopathy were more common in patients with parapharyngeal and retropharyngeal abscesses and for patients with a more complicated clinical course. The difference in the set of symptoms might be explained by the different anatomical locations of the abscesses and therefore a diverse capability to cause symptoms. Patients that presented with a parapharyngeal or retropharyngeal abscess also presented with a higher mean CRP count (158 or 146 compared to 71).

The rate of complications was fairly high (9.6%) compared with the reported 4.4-9.4% in the literature (16,28,38,51). One reason to the higher rate of complications could be that pneumonia was counted as a complication. The studies referred to in the present study, only counted life-threatening complications and excluded pneumonia (1,7). If pneumonia is left uncounted, in this study, the rate of complications would be 6.5%, which is closer to the percentage reported in the literature. All of these abscesses were located in the parapharyngeal or retropharyngeal areas. It should be noted that in this study the focus was on complications of the disease and therefore complications of the treatment (i.e. nerve trauma during surgery) were not paid attention to.

The culture results were consistent with those reported in the literature with *Staphylococcus aureus* and *Streptococcus pyogenes* being the most commonly cultured pathogens (1,28,32,33,38,51,52). A majority of *Staphylococcus aureus* ($N=7$) presented during the latter half of the time period. This could mean that the pathogen is becoming more common. In contrast to the literature (16,52,55) a risen incidence of methicillin-resistant *Staphylococcus aureus* (MRSA) was not noted in this study as no cases of MRSA was present. A connection could not be established between the causative pathogens and the complications since only 2 out of 6 patients had reliable pus cultures obtained. They presented with *streptococcus pyogenes*. Elsherif et al. did, however, not note a connection in a larger patient population either (13).

Due to the low amount of medically treated patients (15%, $N=9$) it would not be reliable to compare the effectiveness, safety and outcome of medical versus surgical treatment in this study. Therefore, it was not possible to compose a reliable treatment guideline for pediatric deep neck infections due to a lack of supportive data, which has also been noted in other reports (4,6).

Since this study was performed as a retrospective chart review there are certain limitations to the study. These are seen primarily in the form of an occasional lack of available data and a possible lack of uniform variable reporting on the patient charts. These same limitations are however shared by other researchers too. A lack of national treatment guidelines for pediatric deep neck infections also composes a factor of unreliability in the study since the initial choice of treatment is affected by the knowledge and experience of the medical doctor working at the ENT emergency outpatient clinic.

7 CONCLUSION

According to this study the occurrence of pediatric deep neck infections seems to be relatively low in the patient population of the Helsinki University Hospital referral area. Between the years of 2001 and 2010 the amount of patients was between three and eleven patients each year. The number of parapharyngeal and retropharyngeal abscesses was even lower on a yearly level.

The management and treatment outcome of pediatric neck abscesses in our department is in line with other reports. The use of MRI for imaging had increased which is also recommended to diminish the radiation in children. Despite the chosen treatment modality, the children seemed to recover well and the risk of serious complications was low. Multiresistant bacteria were not found and therefore there is no need for primary broad-spectrum antibiotics.

On contrary to an earlier presumption, the prevalence of conservative treatment did not increase during the studied time period. According to the results of this study surgical drainage has remained the principal treatment modality for the patient population at the Department of Otolaryngology – Head and Neck Surgery at the Helsinki University Hospital (HUH). Due to the low amount of conservatively treated patients it was not possible to create a reliable treatment algorithm for pediatric deep neck infections. However, in light of the literature and the treatment outcome of this study it does not seem that a choice of conservative treatment would remarkably raise the possibility of complications or extend the length of the hospital stay. Therefore, initiation of conservative treatment of a pediatric deep neck abscess and close follow-up will be sufficient if the patient is in stable condition.

In conclusion, further studies would be recommended in order to compose national and evidence-based treatment guidelines for pediatric deep neck infections.

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